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Chapter 5: Local Action Plan Best Bets **Infrastructure**

DOCUMENT CONTENTS

Light-Emitting Diode (LED) Traffic Signals

Many cities have begun replacing their old incandescent halogen bulb traffic lights with much more energy efficient and durable light-emitting diode (LED) traffic lights. LED arrays in the new traffic lights include hundreds of individual LEDs each the size of a pencil eraser. There are three principle advantages to upgrading municipal traffic lights to LEDs:

1. LEDs are brighter. LED traffic lights emit light more evenly, making them brighter overall and more visible in foggy conditions.
2. LED traffic lights last for 100,000 hours, compared to incandescent bulbs, which have filaments that burn out and may last only 8,000 hours before needing to be replaced. Replacing bulbs costs money for materials and labor and the replacement inhibits traffic flow. Fewer burned-out lights increases safety of intersections.
3. LEDs consume less energy, about 85% less than incandescent bulbs.

Typical incandescent traffic lights use 100-watt or 150-watt bulbs that are operating 24 hours a day, utilizing more than 2.4 kilowatt-hours per day. At 8 cents per kilowatt-hour, one intersection can cost almost $600 per year in electricity. Large cities with thousands of intersections spend millions of dollars on electricity just for traffic lights. LED arrays consume 12-20 watts instead of 100, reducing overall energy consumption considerably. Portland spent $2.1 million to change out red and green traffic lights to LEDs and received a 4-year payback on the project.[1] Solar panels can power LED traffic lights in remote areas, reducing the costs of installing power lines.

[1] Personal communication with David Tooze, Portland's Energy Specialist.

Another benefit of LED traffic signals is the fact that they do not burn out all at once. When an incandescent filament burns out, the entire light ceases to function. In an LED, a single diode or a cluster of diodes can stop working or burn out, but the other diodes operating independently will continue to function normally. This feature eliminates the safety risks and traffic congestion problems of burnt-out traffic signals.

LED Traffic Signals

CASE STUDY: Sacramento, CA

Between 1994 and 2004, the city of Sacramento upgraded the traffic lights in more than 1,000 of its 1,300 intersections. The decade-long conversion from incandescent lamps to LEDs has reduced the energy consumption by the Sacramento Municipal Utility District (SMUD) by a total of 1.4 megawatts. When all the intersections are completed, the estimated energy savings will be an estimated 2 megawatts.

Despite initial skepticism concerning the value of upgrading to LEDs given the higher upfront costs, the SMUD invested in the conversion of its first major intersection in April of 1995. The city's 30-day electric bill for that intersection dropped from $148 to $21.40.[2] Current overall savings of the traffic light upgrades across Sacramento County are an estimated $557,000 a year.

Additional financial incentives provided by the SMUD include rebates of about $225 for each on-peak kilowatt that the city and county reduce.

A policy encouraging the upgrade of traffic lights to LEDs by the California Energy Commission (CEC) has resulted in the conversion of over 13,000 intersections throughout the state. The stated goals of the policy are to assist local government agencies in saving money, conserving energy to avoid crises like the blackouts of 2001 and increasing the overall safety of intersections. The CEC offers loans and grants to local agencies for the implementation of LED upgrades.

Results of the CEC incentive program include the replacement of nearly 250,000 old incandescent red, green and amber traffic signals, along with pedestrian walk and do not walk signals, with new LED lamps. The new LED lights reduce the State's need for electricity by nearly 10 megawatts, enough electricity to power nearly 10,000 homes.

The reduced electricity demand should save the state an estimated $7.9 million every year on electricity costs.

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[2] SMUD, LED Traffic Signals, www.smud.org/education/led.html, 22 September 2006.

LED Traffic Signals

CASE STUDY: Chicago, IL

The city of Chicago has an estimated 2,800 intersections. Through a joint venture between the Chicago Department of Transportation (CDOT) and the City's Bureau of Electricity, old traffic lights at 350 intersections have been replaced with LED traffic signals. According to Matt Smith, Director of Communications at CDOT, the new LED traffic signals have demonstrated their efficiency through significantly reduced energy costs.[3] The city estimates that it will save $2.5 million annually by retrofitting all of its intersections. The program has already reduced the city's annual CO_2 emissions by 7,250 tons.

An added benefit of switching to LEDs is the ability to use backup power supply for traffic signals during power outages. In conjunction with the LED retrofit program, the city of Chicago has installed PowerBack ITS Systems at approximately 800 new and existing traffic intersections. The PowerBack ITS System is a complete battery backup system for traffic signal intersections that keeps traffic signals on when the power goes out. The PowerBack ITS Series will operate traffic signals after a power outage in either normal or "flash" mode for up to 24 hours. Although such backup power supplies can be used in traditional incandescent traffic signal systems, they provide a much longer range of emergency coverage with more energy efficient LEDs.

CDOT has also begun implementing the use of activated or actuated traffic signals that can detect when a vehicle is in the intersection. This network of vehicle detectors automatically detects traffic movement and patterns and allows automated adjustments of the traffic signal operation to streamline the flow of traffic. Stop-and-go traffic wastes energy since gasoline-powered cars use almost as much energy idling as driving. Timing traffic lights, particularly during commuting hours in the commuting direction, will alleviate congestion and excessive stop-and-go traffic. The results of CDOT's integrated traffic management program are a better understanding of traffic patterns, better coordinated traffic signals at any particular intersection, increased efficiency of traffic flow, and fewer accidents.

Mayor Daley's Traffic Management Task Force meets regularly to review major construction projects and special events that are likely to have significant impact on the city's traffic. Members of CDOT, the Mayor's Office, and other key city departments and agencies work with media outlets to design solutions and inform the public on road closures, alternate routes and traffic advisories.

CONTACT

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[3] U.S. Mayors Best Practices Database, www.usmayors.org/uscm/best_practices/traffic/best_traffic_initiative_chicago.htm, 22 September 2006.

LED Traffic Signals

CASE STUDY: Berkeley, CA

The city of Berkeley received more than $225,000 in rebates from the utility, Pacific Gas & Electric (PG&E), for replacing nearly 3,000 traffic signal bulbs with energy-efficient LED fixtures.[4] The city replaced old red and green traffic incandescent bulbs over several years as part of an energy conservation program sponsored by PG&E. Amber bulbs, since they are used so infrequently, are seldom replaced and are usually the last priority for replacement in municipal retrofit projects.

According to the city of Berkeley's Climate Action Plan[5], the retrofit costs for LED traffic signals are as follows:

- 8" diameter red lights $170 each
- 12" diameter red lights $240 each
- Pedestrian control lights $160 each

LED technology has experienced significant growth in recent years and these prices will likely continue to decrease with time.

The city of Berkeley estimated that it will reduce its energy use for traffic signals by more than 563,000 kWh, which is roughly equivalent to $56,000 per year of reduced energy costs.[6] According to Neal DeSnoo, energy officer for the Office of Energy and Sustainable Developed for the city of Berkeley, actual energy savings from 1998 to 2005 were 890,000 kWh for all the signals and exceeds the original estimate of 563,000 kWh. Meter measured energy savings has been reduced from 1,341 kWh in 1998 to 451 kWh in 2005—approximately 66% in savings. Additional savings in reduced maintenance costs increase the payback rate of the upgrade investment. The amount of electricity saved also equates to the reduction of 323 metric tons of CO_2.

Following The California Energy Commission's (CEC) recommendation that cities optimize their traffic signals every three to five years, the city of Berkeley integrates signal coordination and traffic flow management into its transportation plan. According to the CEC, cities participating in CalTran's Fuel Efficient Traffic Signal Management (FETSIM) program reduced gasoline use by 19%. As an added benefit, travel time was also reduced by an average of 7.5%.

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Traffic Flow Management Systems

Traffic flow management consists of set light timing, activated traffic signals, signal synchronization and more techniques that work to improve traffic flow. With these programs commuters should experience a reduction in travel time, less gas consumption and cost savings due to the coordination of signals. These strategies reduce air pollution and GHG emissions caused by idling.

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[4] Berkeley Press Release, January 2003, www.ci.berkeley.ca.us/news/2003/01jan/011403energyrebate.html, 22 September 2006.
[5] Berkeley Climate Action Plan, www.baaqmd.gov/pln/GlobalWarming/BerkeleyClimateActionPlan.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Berkeley_CAP.pdf, 29 September 2006.
[6] Ibid.

Traffic Flow Management

CASE STUDY: Colorado Springs, CO

The city of Colorado Springs, Colorado traffic signal timing team studies 30-40 arterial streets each year to determine optimal traffic flow coordination.[7] In 2005, the city released the Traffic Signal Coordination Planning Effort Report that describes the potential upgrades and new technologies the city could adapt to minimize traffic.[8]

In the report the city recognizes the potential time and cost saving benefits traffic flow management can have. "Each dollar spent optimizing signal timing and implementing system improvements can yield up to $40 in fuel savings." "As national studies indicate, coordinating previously uncoordinated signals can result in a reduction in travel time ranging from 10% to 20%. According to our own recent studies conducted along Academy in February, there is a 10% to 30% improvement in travel times resulting from coordinated signals."

The key systems Colorado Springs uses to coordinate their traffic flow include:

- Communications Links to Signals
- Traffic Signal Controller Equipment
- Advanced Traffic Detection System

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High Efficiency Street Lighting

According to a review conducted by the California Energy Commission, street lighting accounts for as much as a quarter of a municipality's electric bill.[9] The choice of what kind of street lighting to use affects the city budget as much as it influences the city's ambience. New technologies in lighting provide more efficient ways to effectively illuminate neighborhoods and public spaces. The quality and brightness of street lighting does not need to be compromised in order to significantly reduce the amount of electricity consumed.

High Pressure Sodium Lamps

High pressure sodium lamps (HPS) are a very popular option for municipal street light systems across the country. HPS lighting is 57% more efficient than incandescent street lamps and 32% more efficient than mercury vapor lamps. HPS lamps produce 90-150 lumens per watt[10] (compared to 30-48 lumens per watt in mercury vapor lamps).[11] HPS street lighting systems have a payback period of about six years compared to mercury vapor lamps.[12] However, the orange-yellow light produced by HPS lamps does not contain light in the blue spectrum, diminishing people's ability to use peripheral vision at night. It also does not render colors as well as other lamp types.

Low Pressure Sodium Lamps

Low pressure sodium lamps (LPS) are even more energy efficient than HPS lamps. They were designed to operate at low

[7] Colorado Springs, Traffic Flow Coordination website, www.springsgov.com/Page.asp?NavID=2482, 5 December 2006.
[8] Traffic Signal Coordination Planning Effort, www.springsgov.com/units/traffic/SignalCoordinationPlan.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/ColoradoSprings_SignalCoordinationPlan.pdf, 5 December 2006.
[9] Currents: An Energy Newsletter for Local Governments, www.lgc.org/freepub/PDF/Energy/currents/09_streetlighting99.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LGC_newsletter.pdf, 29 September 2006.
[10] Ibid.
[11] City of Los Angeles, Environmental Affairs Office. 2001. Los Angeles Energy Climate Action Plan is under revision in October 2006. also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LAClimateActionPlan.pdf, 25 September 2006.
[12] Currents: An Energy Newsletter for Local Governments, www.lgc.org/freepub/PDF/Energy/currents/09_streetlighting99.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LGC_newsletter.pdf, 29 September 2006.

temperatures and maintain luminance throughout the lamps' lifetime. The light produced by LPS lamps is a dull yellow color, does not allow for effective peripheral vision, and does not render colors well. It is the lighting of choice around observatories since the monochromatic light can be filtered by telescopes. LPS color limitations make it difficult to use. Therefore, the intensity of sodium lamp lighting levels may need to be adjusted to perform as well as lower wattage, wider spectrum white lighting.

Metal Halide Lamps

Metal halide lamps use an electric current that passes through a gas to create light. The bright white light is very effective for rendering colors at night and does not adversely affect peripheral vision. Metal halide lamps produce large amounts of heat and can burn out quickly. The brightness of the lamps also creates a high potential for glare. Metal halide lamps are twice as energy efficient as the mercury vapor lamps they replace. Metal halides require 60-100 lumens per watt and last on average 10,000-15,000 hours.[13]

Induction Lighting[14]

Induction lighting uses the energy from a magnetic field combined with a gas discharge to create light. It is very energy efficient, has a long life, and produces a high-quality white light. While the other lamp types last on average between 10,000-30,000 hours, the induction lamp has a100,000-hour life span. Because it is a relatively new technology, induction lighting still has a high upfront cost. The greater efficiency and lower maintenance costs can help to offset the additional cost of the system over the life of the bulbs.

Table: The Pros and Cons of Lamp Options[15]

	Pros	*Cons*
MERCURY VAPOR	Inexpensive to install and purchase Medium life Dimmable Good color rendering due to white light	Expensive to operate due to inefficiency Tend to be glary due to intense light Dramatic lumen depreciation over time Use hazardous material (mercury)
HIGH PRESSURE SODIUM	Energy efficient Widely used, reliable Medium life	Orangish-yellow light Safety concerns due to color rendition Cannot restrike immediately
LOW PRESSURE SODIUM	Very energy efficient, medium life Minimum glare Able to restrike immediately Do not attract most insects	Orangish-yellow color Safety concerns due to color rendition Expensive fixtures
METAL HALIDE	Good color rendering More efficient than mercury vapor Widely used	Short life, high maintenance Less efficient than HPS, LPS and Induction High temperatures burn out ballasts
INDUCTION LIGHTING	Energy efficient Low maintenance costs due to long life Good color rendering due to white light Immediate ignition & re-ignition No flickering	High initial cost Difficult to retrofit existing fixtures Use small amounts of mercury Not dimmable Need a high-frequency generator

[13] Ibid.
[14] Induction Lighting, www.imsasafety.org/journal/septoct04/7.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/InductionLamps.pdf, 25 September 2006.
[15] Local Government Commission newsletter www.lgc.org/freepub/PDF/Energy/currents/09_streetlighting99.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LGC_newsletter.pdf, 29 September 2006.

Lamp and Light Fixtures

A significant factor in the efficiency of a street lighting system is the orientation and design of the lamp and light fixtures. By focusing light in the direction it is most needed, a light fixture can decrease the total amount of light needed. Additional factors affecting a light fixture's overall efficiency include the lamp's height, the distance between poles, and the fixture's cutoff angle. The most efficient streetlight design is the full cutoff fixture since it does not waste light into the night sky.

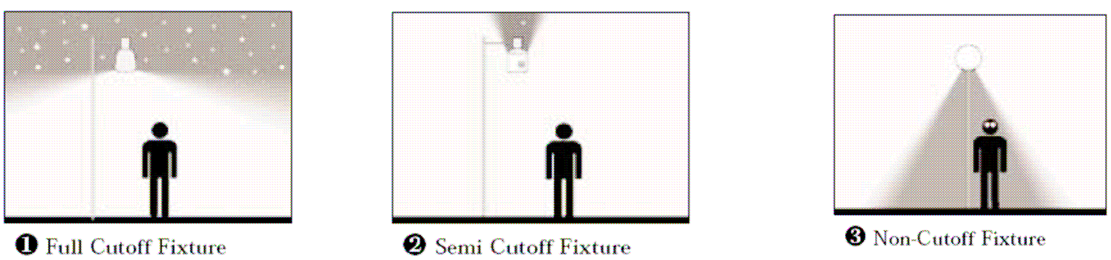

Image: from International Dark Sky Association[16]

Remote Streetlight Control

A new technology allows cities to remotely program when streetlights dim or turn off depending on levels of pedestrian and vehicle traffic. The application may offer significant energy and operational savings. Advocates of the new technology claim that the ability to remotely control street lights could cut energy consumption by as much as 40%.[17] A field study conducted in Vancouver, British Columbia, found that one such program, the Lumen IQ system,[18] reduced electricity consumption for streetlights by 25%. Estimated payback for 100, 250 and 400 watt lamps are 2.68, 1.26, 0.82 years respectively.[19]

High Efficiency Street Lighting

CASE STUDY: Medford, MA

The city of Medford has approximately 4,600 streetlights. Although the local electricity utility owns the majority of the streetlights, the city pays the electricity bill. It has worked closely in conjunction with Massachusetts Electric to convert all of the city's old mercury vapor lamps to HPS lamps.[20] According to the city of Medford's Climate Action Plan,[21] the city expects to save nearly $20,000 annually on its electricity bill and will reduce its CO_2 emissions by 148 tons.

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[16] International Dark Sky Association, www.darksky.org/index.php, 25 September 2006.
[17] "Streetlight Intelligence Teams With Honeywell to Improve Energy Efficiency," *Business Wire*, 17 November 2005.
[18] www.streetlightiq.com/products/STI_lumenSIMS.html, 22 September 2006.
[19] These estimates are based on turning lights off and no cycling or photo control problems, www.bpa.gov/energy/n/tech/energyweb/docs/SlidesPubs/Smart%20Pack_short%20presentation.ppt, 31 October 2006.
[20] Medford Clean Energy Committee, www.medfordcleanenergy.org/index.html, 30 October 2006.
[21] Medford Climate Action Plan 2001, www.massclimateaction.org/pdf/MedfordPlan2001.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/MedfordPlan2001.pdf, 25 September 2006.

High Efficiency Street Lighting

CASE STUDY: Flagstaff, AZ

More than half of the city of Flagstaff's street lights are low-pressure sodium lamps. Municipal regulations that limit the total number of lumens per acre have encouraged the conversion of the city's streetlights to LPS. Many citizens of Flagstaff comment[22][23] on the positive effects that the lower light levels have on stargazing. The Flagstaff Police Department does not believe that the lower light levels have caused a negative effect on witness or vehicle identification for crime investigations.[24]

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High Efficiency Street Lighting

CASE STUDY: San Diego, CA

The Gaslamp Quarter in San Diego is a busy pedestrian area with many shops, restaurants and outdoor events. The city of San Diego retrofitted 179 HPS light fixtures with induction lighting in the 16-block Gaslamp Quarter to enhance the ambience and safety of the night-time environment. The city saves approximately $12,700 a year in maintenance and energy savings from the retrofit. Over the lifetime of the induction lighting system, the lamps of the HPS system would have had to be replaced about four times. The induction lamp is also brighter than an HPS lamp of the same wattage. Although the HPS lamps are more efficient in lumens per watt, the city saves energy by utilizing a lower wattage induction lamp. The induction lamp system has been praised by San Diego residents for the whiter and fuller light it produces.[25]

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[22] "Residents warming up to yellow-lit road" (*Arizona Daily Sun*, 16 Sept. 1987). www.nofs.navy.mil/about_NOFS/staff/cbl/LPSnet/ADS.870916.html, 22 September 2006.

[23] "Romantics, stargazers make case for adding yellow lights" (*Arizona Daily Sun*, 23 October 1987) www.nofs.navy.mil/about_NOFS/staff/cbl/LPSnet/ADS.871023.html, 22 September 2006.

[24] Letter from Flagstaff Police Department, www.nofs.navy.mil/about_NOFS/staff/cbl/LPSnet/FLAGPDonLPS.doc, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/FlagstaffPD_LPSletter.pdf, 25 September 2006.

[25] Currents Newsletter, www.lgc.org/freepub/PDF/Energy/currents/09_**street**lighting99.pdf, also archived www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LGC_newsletter.pdf, 29 September 2006.

Increase Efficiency of Municipal Water and Wastewater Utilities

About 3% of the nation's electricity supply is consumed by water and wastewater utilities.[26] Water and wastewater systems spend about $4 billion a year on energy to pump, treat, deliver, collect and clean water.[27] This cost can account for as much as one-third of a municipality's total electricity bill.

Many systems operate at less than optimal efficiency. Causes of inefficiency in a water or wastewater system include:

Incorrectly selected and inefficient pumps

Limited capacity in transmission and distribution systems

Lack of automatic or remote control of pumps/ valves

Buying power at peak price times

Operator error

The Environmental Protection Agency (EPA) ENERGY STAR® program has recently expanded its industrial component to include an evaluation of water and wastewater energy performance.[28] The new program estimates that a 10% reduction in energy use at publicly-owned water and wastewater utilities through cost-effective investments and technology upgrades can save 5 billion kWh of electricity and over $400 million annually. The upgrades can also result in a significant reduction of total water consumption.

The primary objectives of a municipal water/wastewater system are to supply the water demanded by the public and maintain water quality while minimizing capital costs. Small publicly-owned utilities may believe that they cannot justify a significant investment to reduce the energy costs for a water/wastewater system if the total energy costs are relatively small. However, many efficiency upgrades can provide significant cost savings with a relatively small capital investment.

Large utilities can achieve significant cost savings with a whole-system approach to identifying sources of inefficiencies in their pumping systems.[29] Life cycle cost analysis can provide insight into the total returns on investment a utility can expect from a more efficient system.

The best way to identify significant cost saving opportunities within a water/ wastewater system is to perform an audit. Audits identify the different areas where inefficiencies exist and present costs of implementation and potential savings. Many private energy consulting companies provide such specialized energy audits.

The best bets for significant energy savings in water/wastewater facilities include: [30]

Manage demand to avoid peak electric rate periods

Modify or replace inefficient pumps

Install energy efficient motors

Control pump speed and flow electronically with variable frequency drives

Install efficient lighting

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[26] EPRI, 1996a, Water and Wastewater Industries: Characteristics and Energy Management Opportunities, Series CR-106941, St. Louis, MO.

[27] Energy Star Water and Wastewater Energy Focus Program Fact Sheet, available online: energystar.gov/ia/business/government/wastewater_fs.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/EnergyStar_wastewater.pdf, 29 September 2006.

[28] Ibid.

[29] For more information on cost-saving opportunities, see the following document(s):
1. Todd Elliot, "Energy-Saving Opportunities for Wastewater Facilities: A Review,"Prepared for Energy Center of Wisconsin, June 2003. www.ndwrcdp.org/userfiles/WU-HT-03-33.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Elliot.pdf, 25 September 2006.
2. Alliance to Save Energy "Watergy" Project, www.watergy.org, 22 September 2006.

[30] EPA Wastewater Management Fact Sheet, www.epa.gov/owm/mtb/energycon_fasht_final.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/EPA_WWTP.pdf, 30 October 2006.

Implement training programs to reduce worker error

The use of renewable energy or fuel cells for power can also increase efficiency, although the initial costs are greater than the other measures listed above.[31] Utilities can reduce the total electricity needed to provide the required services, including replacement of inefficient pumps and motors or minimize the flow rates of water and wastewater on the consumer side through educational campaigns and strategic pricing. Any municipal policy that aims to increase the overall efficiency of a water/wastewater utility should include a combination of both.

Water and Wastewater Efficiency

CASE STUDY: Columbus, GA

The city of Columbus, Georgia has saved over $1 million in energy costs over the past five years by overhauling its water utility.[32] The Columbus Water Works is a municipally-owned water and wastewater utility that provides services to the community of 186,000 people. An analysis performed by the Water Works identified energy costs as the utility's largest single expenditure. Through a process of reengineering and retrofitting old equipment, the city increased the water system's energy efficiency and cut energy costs significantly.

The retrofit included many different elements. The entire wastewater and drinking water treatment system was reengineered to be fully automated. Old motors throughout the system were replaced with more energy efficient models. Automated motor operators retrofitted onto the system's compressed air blowers reduced the utility's energy costs by 25%, with less than a one year payback.[33] An energy consultant evaluates the utility's energy use every quarter and recommends improvements.

Employees are encouraged to make recommendations for efficiency improvement projects. Managers and team leaders attend biannual trainings on energy efficiency.

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Water and Wastewater Efficiency

CASE STUDY: Fairfield, OH

Fairfield Wastewater Treatment Facility in Ohio provides services to 45,000 people. Since 1986, the utility has increased the energy efficiency of its operations through an automated system and continuous technology upgrades.

In 1999 the Wastewater Division implemented a real-time rate-pricing program using data from previous years to calculate an energy usage baseline. When electricity prices peak, the facility uses its automated system to shut down temporarily and save money. This system has shifted 35–40% of peak loads to cheaper, off-peak periods, resulting in energy bill reductions of up to 17%.[34] Continuous monitoring of the system's operations and energy use allow

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[31] King County Fuel Cell Demonstration Project, dnr.metrokc.gov/wtd/fuelcell/, 5 December 2006.
[32] "Watergy Taking Advantage of Untapped Energy and Water Efficiency Opportunities in Municipal Water Systems", 2002, www.ase.org/uploaded_files/watergy/watergyfull.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Watergy_2002.pdf, 22 September 2006.
[33] Ibid.
[34] Ibid.

the utility to maintain optimal performance

Fairfield's utility management uses a general set of guidelines to facilitate investment decisions in energy efficiency upgrades. The Fairfield Wastewater policy states that efficiency upgrades that cost less than $15,000 and have a payback of less than five years receive automatic authorization. This process gives project managers much more flexibility in including such upgrades in their annual budgets.

There is a 21-member team composed of operations staff members that meets regularly to discuss new technology and energy efficiency ideas. Fairfield Wastewater also encourages feedback and input from staff at weekly operations meetings.

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Water and Wastewater Efficiency

CASE STUDY: Austin, TX

The city of Austin Water and Wastewater Utility provides services to over 600,000 people. The semiarid climate of Central Texas requires the city of Austin to manage its water resources wisely. The hilly terrain places a heavy demand on the utility's pumping system.

To reduce the overall energy use of pumping water through the transmission and distribution system, members from several departments meet regularly to share ideas for improving the efficiency of the utility's pumping system. The ad-hoc committee has implemented measures to upgrade the system's pumps to more efficient models and to limit pumping to off peak hours.

The Austin Water and Wastewater Utility interfaces with the largest water consumers in the residential, commercial, and industrial sectors. The utility continuously monitors energy use and water flow through a series of submeters throughout the distribution system. This information allows the utility to coordinate repairs and upgrades more efficiently. Austin reports a rate of total water loss through its distribution system of only 8%.[35]

The utility also monitors water consumption of up to 30 categories of water users, such as hospitals and schools. This data allows the utility to focus its demand-side management efforts on the most egregious wasters of water.

The water utility offers a sizeable incentive to industrial customers for reducing long-term water consumption. The water utility pays one dollar for every gallon of water consumption reduced per day for up to $40,000 per company. This one-time payment is available to customers of all sizes who make lasting efficiency improvements to their systems.

The city of Austin recently upgraded the pumping system at its municipal power plant, saving millions of dollars a year.[36]

The city of Austin recently passed a municipal bond authorizing the installation of a reclaimed water pumping system. Any non-potable water users can connect to the system and purchase the cheaper reclaimed water. Clients include industrial users and irrigation companies. The system has a capacity to recycle up to 40 million gallons per day. This greatly reduces the demand for Austin's clean water resources and decreases costs for wastewater treatment.

The utility also markets its water efficiency improvement programs and educates consumers. Consumers pay an additional 1% on their water bills to fund municipal water efficiency projects.

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[35] Ibid.
[36] For more Austin's pump upgrade project, visit: www.nrel.gov/docs/fy05osti/37537.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/NREL_Austin_spotlight.pdf, 29 September 2006.

Project managers and employees of the Austin Water and Wastewater Utility receive regular updates on system performance and are encouraged to suggest improvements.

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Water and Wastewater Efficiency

CASE STUDY: San Diego, CA

The city of San Diego faces a growing demand for water and an increasingly tight supply. It has the unenviable task of maintaining services while minimizing total water consumption due to increased political pressure from other water-deficient cities and states. The daily volume of wastewater transported and treated in the MWWD facilities requires a considerable amount of electrical and thermal power. Pumps, lights, computers, mechanical valves and machinery consume electricity. Thermal energy, usually generated by electrical power or by burning natural gas, provides heat and cooling necessary for both buildings and the wastewater treatment process. It is in the best interest of the city of San Diego and its residents to maximize the potential of their scarce resources by minimizing the energy and water used to provide necessary services.

The San Diego Metropolitan Wastewater Department (MWWD) established a multi-year strategic plan to mitigate the risk of future energy shortages in goals is to reduce the energy consumed at wastewater facilities by at least 7%. The MWWD has created an Energy Efficiency Program to achieve this goal.
The MWWD Energy Efficiency Program targets cost-effective ways to achieve water and energy savings in the following areas:

Facility and equipment efficiency upgrades

Water reclamation

Capture and reuse of methane

Cogeneration

The energy savings made by the MWWD and the Energy Efficiency Program maintain lower sewer rates and reduce the risk of rolling electrical blackouts due to excessive peak energy demand.

Point Loma Wastewater Treatment Plant[37]
Digesters at the Point Loma Wastewater Treatment Plant use heat and bacteria to break down the organic solids removed from products of this biological process is methane gas, a potent greenhouse gas that can also be used to generate electricity. The gas emitted from waste is approximately 60% to 65% methane, also known as digester gas (DG).

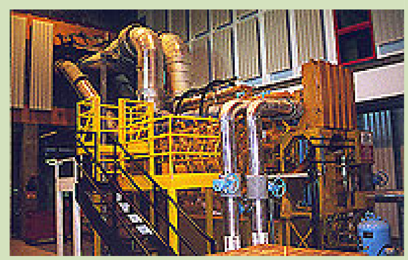

Image: Point Loma Wastewater Treatment [38]

MWWD has installed such cogeneration systems in several of its plants. During fiscal year 2000, one wastewater plant saved the city of San Diego more than $500,000 in energy costs and earned an additional $400,000 from selling excess power back to the grid.[39]

California government grants make cogeneration projects more cost-effective. Current grants are approximately $1,000/kW for reciprocating

[37] Point Loma Wastewater Treatment Plant, www.sandiego.gov/mwwd/facilities/ptloma.shtml, 22 September 2006.
[38] City of San Diego MWWD website, www.sandiego.gov/mwwd/initiatives/energy.shtml, 22 September 2006.
[39] "Watergy Taking Advantage of Untapped Energy and Water Efficiency Opportunities in Municipal Water Systems", 2002, www.ase.org/uploaded_files/watergy/watergyfull.pdf, also archived at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Watergy_2002.pdf, 22 September 2006.

California. One of the city's	wastewater. One of the by-	internal combustion (IC) engines,

$1,300/kW for microturbines, and $4,500/kW for fuel cells on renewable fuels like digester gas and landfill gas.

The city of San Diego complements its energy efficiency upgrades with an aggressive demand-side management policy to minimize the total water consumed by the city. Consumers receive information on how to minimize water consumption. San Diego also treats and reuses wastewater. One of the city's reclamation plants treats up to 30 million gallons of wastewater every day. MWWD sells the reclaimed water at a reduced price to customers for use in landscaping, irrigation, industrial, and agricultural purposes. Pipelines and equipment used in the reclaimed water process are specially marked or color coded to differentiate them from drinking water pipes. MWWD also uses a flow metering alarm system to minimize undetected sewage spills.

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Landfill Gas-to-Energy Projects

As trash decomposes, it produces methane gas, a GHG that traps more than 21 times more heat per molecule than CO_2.[41] Municipal solid waste landfills account for more than a third of human-related methane emissions in the United States.[42] Methane gas comprises about one-half of the volume of landfill gas. The other half of the gas is a mixture of CO_2, other gases and traces of organic compounds.

Landfill gas is recovered using a system of wells and either a blower/flare system or a vacuum system. The gas is pumped to a central collector where it is converted into the appropriate form depending on what its ultimate use will be. Methane can be used to fuel vehicles, supply industrial operations, power an electricity generator or can even be upgraded to higher-quality methane gas for distribution via pipeline. To generate electricity from landfill gas, the methane from the landfill gas is used to power internal combustion engines or turbines. Other technologies for producing electricity from landfill gas are currently under development and may increase the overall efficiency of the process. This process reduces municipal energy costs by providing a low-cost alternative to conventional fossil fuels. Landfill gas that leaks is a wasted economic opportunity.

Capture and use of landfill methane also reduces bad odors and health hazards. A study in the State of New York found that women living near 38 landfills with landfill gas leaking into the surrounding environment have a four-fold increased chance of bladder cancer or leukemia.[43] As with all waste issues, an essential element of the solution to the problem of landfill gas emissions is reducing the quantity of waste generated.

According to the EPA, there are more than 395 landfill gas capture projects in the country and nearly 600 municipal landfills that could qualify for a methane capture retrofit.[44] The potential for electricity production at the remaining landfills would be sufficient to provide power to 900,000 homes.[45]

Since 1979, federal regulations promulgated under Subtitle D of the Resource Conservation and

[40] City of San Diego, Metropolitan Wastewater, www.sannet.gov/mwwd/, 29 September 2006.
[41] EPA Global Warming Emissions, yosemite.epa.gov/oar/globalwarming.nsf/content/emissions.html, 22 September 2006.
[42] EPA Landfill Methane Outreach Program, www.epa.gov/lmop/overview.htm#methane, 22 September 2006.
[43] "Investigation of Cancer Incidence and Residence Near 38 Landfills With Soil Gas Migration Conditions, New York State, 1980-1989," State of New York Department of Health, (Atlanta, Ga: Agency for Toxic Substances and Disease Registry, June, 1998). Available from the National Technical Information Service in Springfield, Virginia [800-553-6847]; publication PB98-142144.
[44] EPA landfill map of projects, www.epa.gov/lmop/docs/map.pdf, also archived 25 September 2006 at, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/LandfillGas_ProjectsMap.pdf..
[45] EPA LMOP Benefits, www.epa.gov/lmop/benefits.htm, 22 September 2006.

Recovery Act (RCRA)[46]—which regulates the design and operation of municipal solid waste landfills—have required controls on migration of landfill gas. The regulations require methane monitoring and establish standards for methane migration control. Monitoring requirements apply to a landfill during operation and for a period of 30 years after closure. Landfills affected by RCRA Subtitle D must control gas by establishing a program to periodically check for methane emissions and prevent off-site migration. Gas-to-energy projects facilitate the achievement of these standards by minimizing the quantity of gas underground and by providing a cash flow in the form of energy to offset the upfront costs of the gas recovery infrastructure.

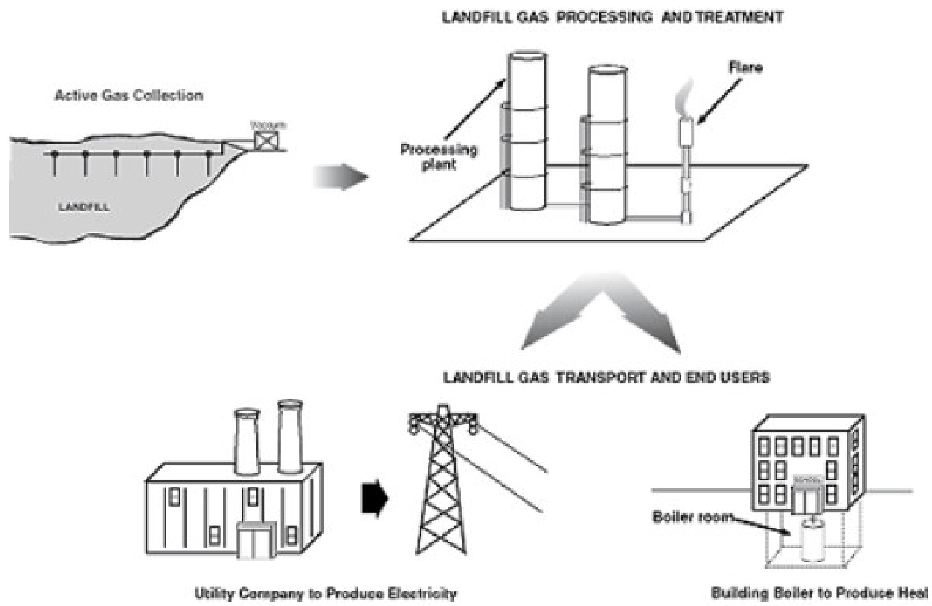

Image courtesy of EPA[47]

Landfill gas can also be used directly in several industrial processes including the operation of boilers, kilns and greenhouses. Most processes that use natural gas or require quantities of heat can substitute the use of landfill gas. The EPA lists the following industries that used landfill gas in their manufacturing and/or industrial processes:

Auto manufacturing

Chemical production

Food processing

Pharmaceuticals

Cement and brick manufacturing

Wastewater treatment

Consumer electronics and products

Paper and steel production

Some landfill gas recovery projects utilize cogeneration to increase the overall efficiency of the recovery and reuse process. The thermal energy produced as part of the electricity generation process can be stored in the form of steam or hot water and used for heating, cooling or other applications.

Landfill gas recovery and reuse:

Reduces emissions of a potent greenhouse gas

Offsets use of non-renewable sources of energy (natural gas, coal, oil)

Provides low-cost source of electricity

Minimizes odors emitted from landfills

[46] RCRA Regulations: www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr258_00.html, 22 September 2006.
[47] EPA LMOP, www.epa.gov/lmop/over-photos.htm#3, 27 September 2006.

Eliminates health risks associated with organic compounds in landfill gas

Reduces risk of explosion from built-up methane gas pockets

Benefits local economy

Reduces cost of compliance with local, state and federal air quality regulations

Landfill Gas to Energy Projects

CASE STUDY: Los Angeles, CA

The Sanitation Districts of Los Angeles County (Districts) began recovering the estimated 26,000 cubic feet per minute (cfm) of landfill gas generated at Puente Hills Landfill, the largest landfill in the nation, in the 1980's.[48] The intent of the landfill gas collection project was to minimize landfill gas emissions to the atmosphere and limit below-ground migration of the gas in accordance with federal regulations. The Districts originally used the landfill gas to fuel an electricity production facility that has been operating at the site since January of 1987. After noticing that a percentage of the gas was not being utilized and had to be flared, the Districts decided to begin converting that gas to vehicle fuel.

In October of 1993, the Districts opened the country's first facility to convert landfill gas to vehicle fuel. Wells inserted deep into the landfill capture the gas and transport it to a processing facility where it is purified through membranes to remove CO_2 and water vapor. The resulting compressed natural gas (CNG) is used as a fuel for landfill equipment, garbage trucks, water trucks and employee rideshare vans.

Landfill gas from Puente Hills is also transported to the Districts' Joint Administrative Office where it is used for heating and cooling. The Districts also sell a portion of the gas to Rio Hondo College for heating school facilities and for powering a CNG vehicle.

The Puente Hills gas-to-energy facility produces enough CNG fuel for a fleet of 11 vehicles and produces about 50 megawatts of power, enough to provide electricity to 70,000 homes. The Districts operate two smaller gas-to-energy facilities, Palos Verdes (6 MW) and Spadra (8.5 MW). Since the capital costs of all three facilities have already been recuperated, the Districts only pay for maintenance and operation costs of the facilities. This amount is more than offset by the sale of electricity to local utilities. In 1997, electricity sold from the Puente Hills facility alone amounted to $16.5 million in net revenues.[49]

Puente Hills Landfill

Image courtesy of Los Angeles County Sanitation District[50]

[48] LA County Sanitation Districts, www.lacsd.org/swaste/Facilities/LFGas/CNGFacility.htm, 22 September 2006.
[49] LA County Sanitation District, www.lacsd.org/swaste/Facilities/LFGas/Gas-To-EnergyFacilities.htm, 27 September 2006.
[50] LA County Sanitation District, www.lacsd.org/swaste/Facilities/LFGas/CNGFacility.htm, 27 September 2006.

The project prevents the release of large quantities of landfill gas to the atmosphere and helps minimize the accumulation of nitrogen oxides (NOx) that contribute to the formation of smog. With greenhouse gases now being regulated in California, the project may potentially minimize the regulatory costs of compliance that other landfills without gas recovery mechanisms may face.

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Landfill Gas to Energy Projects

CASE STUDY: Riverview, MI

The city of Riverview, Michigan, owns and operates the Riverview Land Preserve landfill in Wayne County. In a joint project with the local utility, Detroit Edison, the city recovers and sells landfill gas to generate energy. The partnership began in 1987 with the development of a landfill gas-to-energy project on the 212-acre landfill. A subsidiary of Detroit Edison collects the gas and sells it to Riverview Energy Systems, where it generates electricity in two gas turbines. Detroit Edison then purchases the electricity under a 25-year power purchase agreement. The gas-to-energy project provides enough electricity for 3,700 homes.

The city has achieved attainment of federal methane gas migration requirements at its landfill in a cost-effective way. The project provides revenue directly to the city as stipulated in the terms of the contract. Since the installation of the project facilities, property values surrounding the landfill have increased and new neighborhoods have been constructed. The so-called "Mount Trashmore" that was once an eyesore and a safety hazard has also been turned into a wintertime skiing and recreation area.

The Riverview gas-to-energy project is a good example of local governments and local industries collaborating to achieve positive results. Detroit Edison not only receives a locally produced and inexpensive source of electricity, but also the positive publicity that this project continues to generate.[51]

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[51] EPA LMOP Riverview Project, www.epa.gov/lmop/res/riverview.htm, 27 September 2006.

Landfill to Gas Energy Projects

CASE STUDY: Orange County, FL

Orange County's landfill gas-to-energy system collects gas from the 200 acres of waste at the Orange County landfill. The gas is piped to the Stanton Energy Center where it is used to fuel a generator. The landfill produces an estimated 6,000 cfm of gas, enough fuel to generate electricity for 13,000 homes.[52]

The Orange County Solid Waste Department sold the landfill project to DTE Biomass which will own and operate the landfill gas recovery project over the term of a 20-year contract with Orange County. The project received $4 million in federal funding and also benefits from multiple tax incentives.

Orange County recuperated its initial costs with the sale of the project for $5 million and will earn an estimated $400,000 annually on the landfill gas rights. The project reduces methane emissions by 31,000 tons per year.

The Orange County Solid Waste Department worked closely with the EPA's Landfill Methane Outreach Program (LMOP) in the development of this project. The LMOP provides information on technologies to help optimize efficiency and production while minimizing the costs of the gas recovery system. They work with several municipalities across the country in the design and implementation of landfill gas-to-energy projects. Orange County received recognition from the EPA as the 1998 Partner of the Year.

CONTACT

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[52] EPA Landfill Methane Outreach Program www.epa.gov/lmop/res/orange.htm, 27 September 2006.

Additional Resources

LED and Traffic Flow Management:

Margaret Suozzo, A Market Transformation Opportunity Assessment for LED Traffic Signals, April 1998
www.cee1.org/gov/led/led-ace3/ace3led.pdf#search=%22berkeley%20led%20traffic%20lights%20pacific%20gas%22

Optimizing Traffic Light timing through simulations
www.informs-cs.org/wsc04papers/188.pdf

Dallas Light timing program to improve air quality
www.dallascityhall.com/pdf/pio/CooperativeProgram.pdf

U.S. Climate Change Technology Program
www.climatetechnology.gov/library/2005/tech-options/tor2005-114.pdf

California Energy Commission LED Replacement Program
(Has list of project costs for many California cities)
www.energy.ca.gov/releases/2002_releases/2002-03-14_led_signals.html

State of Illinois LED Traffic Signal Rebate Program Application
www.illinoiscleanenergy.org/images/ICEFC_PDFs/2006%20LED%20Application%20Fill-in.pdf#search=%22chicago%20LED%20traffic%20%22

Seattle Department of Transportation Traffic Signal Optimization Program,
www.seattle.gov/transportation/signaloptimization.htm

Institute of Transportation Engineers, Traffic Signal Timing,
www.ite.org/signal/optimization.asp

Efficient Streetlights

Lincoln, NE street lighting policies
www.ci.lincoln.ne.us/City/attorn/designs/ds230.pdf

Issues and Facts about Low Pressure Sodium Lighting
www.nofs.navy.mil/about_NOFS/staff/cbl/LPSnet/LPS-references.html

Lighting Rates for Palo Alto
www.cpau.com/docs/rates/ratespdf/E14-070105.pdf

International Dark-Sky Association
www.darksky.org/

The Local Government Commission (LGC) is a nonprofit, nonpartisan, membership organization that provides inspiration, technical assistance, and networking to local elected officials and other dedicated community leaders who are working to create healthy, walkable, and resource-efficient communities.
www.lgc.org/index.html

Efficient Water and Wastewater Utilities

Consortium for Energy Efficiency (CEE) Resources Page
www.cee1.org/ind/mot-sys/ww/cr.php3

EPA Wastewater Management Fact Sheet
www.epa.gov/owm/mtb/energycon_fasht_final.pdf

Watergy
www.watergy.org

Alliance to Save Energy
www.ase.org

U.S. Department of Energy, Office of Industrial Technology
www1.eere.energy.gov/industry/

Office of Industrial Technology Software Tools
www1.eere.energy.gov/industry/bestpractices/software.html

Wisconsin Wastewater Operator's Association
www.wwoa.org

King County Fuel Cell Demonstration Project
dnr.metrokc.gov/wtd/fuelcell/

World Health Organization (WHO)-Regional Centre for Environmental Health Activities
www.emro.who.int/ceha/clearingh_waterdemand/portals/wutiliz/index.asp

"Major Sources of Efficiency Savings", ***Future Investment in Drinking Water and Wastewater Infrastructure***, November 2002.
www.cbo.gov/showdoc.cfm?index=3983&sequence=6

"Motor System Efficiency in Water and Wastewater Systems: A Call to Action", American Council for an Energy-Efficient Economy, 2002.
www.cee1.org/ind/mot-sys/ww/call.pdf

Green Pages – Service Providers for Municipal Wastewater Treatment Systems
www.eco-web.com/index/category/2.2.html

Lawrence Berkeley National Laboratory Water and Energy Technology Team
water-energy.lbl.gov/index.php?wastewater

Water Conservation Program in Mountain View, CA
The city of Mountain View, California has a very comprehensive water conservation program to provide resources and incentives to both commercial and residential customers. For information on the program, visit: www.ci.mtnview.ca.us/living/water_conservation.htm

Northwest Energy Efficiency Alliance Case Studies
Ellensburg Wastewater Treatment Plant[53]
Kennewick Wastewater Treatment Plant[54]

DMOZ Water Utility Open Directory of Companies
dmoz.org/Business/Energy_and_Environment/Utilities/Water/

City of San Diego Metropolitan Wastewater Energy Efficiency Program
www.sandiego.gov/mwwd/initiatives/energy.shtml

Water and Wastewater International Publication Article on Cogeneration for Municipal Wastewater
ww.pennnet.com/Articles/Article_Display.cfm?Section=ARTCL&ARTICLE_ID=254314&VERSION_NUM=2&p=20

Anaerobic Digester Methane to Energy A Statewide Assessment, 2003, Prepared for Focus on Energy
www.focusonenergy.com/data/common/pageBuilderFiles/Anaerobic_Report.pdf

Landfill Gas to Energy:

EPA Landfill Methane Outreach Program
www.epa.gov/lmop/

Landfill Gas Control Measures
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
www.atsdr.cdc.gov/HAC/landfill/PDFs/Landfill_2001_ch5.pdf#search=%22riverview%20michigan%20landfill%20gas%22

EPA LMOP Database of Participating Municipalities
www.epa.gov/lmop/proj/xls/lmopdatami.xls
(link to Excel spreadsheet)

More Case Studies
www.epa.gov/lmop/res/index.htm#4

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[53] Case study archived, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Ellensburg_case.pdf, 27 September 2006.
[54] Case study archived, www.natcapsolutions.org/ClimateManual/Cities/Chapter5/BestBets/Infrastructure/Kennewick_case.pdf, 27 September 2006.